SNS Beam Scrubbing, S.Y. Zhang, 10-7-02

1. Scrubbing Effect

- In SPS, there was a scrubbing run of 10 days in April, 2002. LHC required beam was achieved at the injection in first time.
- The scrubbing parameters are consistent for PSR and two SPS studies.

	Pressure rise	Dose in 24 hrs	Scrubbing effect in 24 hrs
PSR	1e-7	0.012	Modest instability threshold increase
SPS 2000	7e-7	0.064	Pressure rise reduced by a factor of 5
SPS 2002	5e-6	0.5	Pressure rise reduced by a factor of 100
Unit	Torr	mC/mm^2	

- Pressure rise is a better indicator for the scrubbing effect, electron dose can also be used (secondary electron energy distribution is similar).

2. A little history

- In 1999, N. Hilleret et. al. proposed LHC beam scrubbing - 1mC/mm^2 may reduce SEY from 2.2 to 1.2, memory is long. Similar results were reported even earlier at KEK, SLAC, and CERN.
- This is a very large dose, in a reasonable period of time, it is always accompanied by very high pressure rise.
- Almost all machines having EC problem, e.g. PSR, SPS serving LHC beam, and PEPII, etc. the instability and/or emittance growth take place when pressure rise to ~ 1e-7 Torr, which contributed little in scrubbing.
- RHIC sees vacuum valve close before the beam instability, probably because EC only takes place in part of warm sections, < 800m / 3800m.

3. SNS pressure rise?

- Pivi-Furman simulation has shown that the SNS peak electron flux on the wall is 5 mA/cm^2, which implies the pressure rise 1.9e-5 Torr, well above threshold, which is 5e-6 Torr.
- It is different from the EC induced beam instability, the pressure rise can be a local problem. Therefore, electron clearing, solenoids at injection and collimators may be needed, even beam is stable.

4. SNS beam scrubbing

- **Scenario 1: Keep the stored beam, 8 minutes dose equals normally one day's. Inject beam with the pressure rise at close to 5e-6 Torr. Once the pressure rise reduces, dump and inject higher intensity beam.**
- **Scenario 2: Add 1 to 2 ms beam storage on the normal operation mode. The dose will be more than 20 times larger than the normal operation. Gradually increase the beam intensity, on daily basis.**
- **Present RF power supply can support ~1 ms storage. A $250k upgrade can support as long as needed (Alex).**
- **Extraction kicker power supply can support longer than 1 ms (voltage drooping). If needed, can keep charging.**
- **Looking for possible limitations, such as beam loss, beam dump, control, possible overheating, ...**

5. PSR as example (R. Macek)

- **We can probably keep the bunched beam in PSR for up to 1-1.5 ms after accumulation . The limit is the buncher rf.**
- **During our electron cloud and e-p instability studies we typically store for 400-500 microseconds after the end of accumulation.**
- **I might check to see if can still store for 1-1.5 ms.**

- **After 2-3 years of beam scrubbing/conditioning at operating conditions at PSR the instability threshold has improved considerably and electrons are reduced. Of course, the inductive inserts were also a help on the instability.**
- **What I would point out is that the electrons seen in the extraction line have not changed much presumably because scrubbing is greatly reduced when the pulse goes by once per accumulation instead of many.**
- **Electrons in the extraction line are now our strongest electron signal by a good factor.**

6. Comments

- **SNS may have vacuum problem, and it might be local problem.**
- **Both beam instability and pressure rise problem can be benefited by beam scrubbing.**
- **PSR could be seen as an evidence of the scrubbing effect, and we may take it as a test bed.**
- **Even with the normal operation mode by adding 1 ms storage time, the impact on the accumulated total beam on the target is significant.**
- **New study at the CERN SPS may have an impact on the thinking we've got used to.**